

The Learning Characteristics of Grapho-Motor Tasks and Their  
Association to Academic Achievements in Kindergarten and  
Grade Two Children in Comparison to Adults

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## **Abstract**

The aim of the current thesis was to examine the association between procedural skill acquisition and academic achievements. Tasks previously used to study procedural skill acquisition are not appropriate in comparing multiple age-groups that include kindergarten children and adults as they are too difficult for the younger children and therefore learning is not demonstrated or too easy for older participants and adults who reach a ceiling effect. Three studies were conducted; the first study examined procedural skill acquisition in relation to motor control strategies in kindergarten, grade two children and young adults using the Mirror Drawing Task, in which subjects were tested over two consecutive days, the second session, 24 hours post training. The aim of the second study was to compare the characteristics of procedural skill acquisition in kindergarten, grade two children and young adults using the Invented letter task (Adi-Japha et al., 2011), a procedural learning task in which participants are tested at initial training, 24 hours post training and in a final 2 weeks post training session (retention). In the third study, we examined the contribution of the procedural learning process using the Invented letter task, to the prediction of academic achievements in concurrent and consecutive years in kindergarten and grade two children. The contribution of three time point measures of the Invented letter task were compared: initial training, consolidated performance 24 hours post-training and retention assessed 2 weeks post-training to academic achievement.

### **Research hypotheses**

First study: 1. Kindergarten, grade two children and adults will exhibit learning and consolidation in terms of the number of correctly executed sides of the square produced (no-error sides) and the error side ratio. 2. Kindergarten children, grade two students, and adults will differ in the type and number of errors committed in accordance with their expected motor control strategies.

Second study: 1. In addition to learning during the training phase, kindergarten children, grade two students, and adults will exhibit similar consolidation gains and retention of the Invented letter Task in terms of overall production time and accuracy. 2. Age dependent differences will emerge in the retention stage of the task.

Third study: 1. Procedural memory measures will predict handwriting speed, legibility

and math in kindergarten and grade two children. Based on Adi-Japha et al., (2011) it is assumed that the 24 h post-training component will predict the best variability in these outcomes. 2. Procedural memory measures will predict handwriting speed and legibility, reading speed, spelling and math assessed a year later. Based on Adi-Japha et al., (2011) it is assumed that the 24h post-training component will predict the best variability in these outcomes.

The first study; The Mirror Drawing Task is a procedural skill acquisition task in which participants are required to trace a diagram while looking at their hand only as a reflection in a mirror. Kindergarteners, grade two children and young adults performed two sessions per day over two consecutive days. The number of sides completed, correctly produced (no-error) sides, error-side ratio (errors divided by sides) and reversals were measured in both the learning and consolidation stages (the improvement from the second session on day1 to the first session on day 2). Our results show that children in grade two and adults improved their performance between days in terms of the number of correct sides produced and the error-side ratio. On average, kindergarten children did not produce even a single no-error side and did not gain in performance between days. The motor control strategies that each age group used in attempting to adapt to the visual distortion differed between the age groups, with kindergarten children using ballistic movements and feedforward motor control in an attempt to adapt to visual distortion while grade two children used long strokes and feedback control suggesting the integration of visual and proprioceptive information. Adults used long strokes demonstrating high speed and accuracy and feedforward control indicating precise spatial representation that does not rely on visual feedback. It is suggested that kindergarteners did not improve between days due to insufficient effective training. Because kindergarten children did not demonstrate learning this task the Mirror Drawing Task was not used in studies two and three.

The second study; Many new skills are acquired during early childhood. Typical laboratory skill learning tasks are not applicable for developmental studies that involve children younger than 8 years of age. It is not clear whether young children and adults share a basic underlying skill learning mechanism. In the present study, the learning and retention of a simple grapho-motor pattern were studied in

three age groups: 5-6 years, 7-8 years, and 19-29 years. The participants practiced the production of the invented letter pattern using a digitizing tablet and were tested post training, 24 hours post training and two weeks post-practice. All age groups produced the pattern more quickly with practice, and the learning rate was inversely related to the initial production time across and within the groups. All groups exhibited additional gains 24 hours post-practice that were well retained two weeks later. The accuracy of the participants was maintained throughout the two-week period. These findings suggest that young children and young adults use a similar mechanism when learning the task.

A separate analysis of the on-page and off-page movement times per block indicated that during retention testing, the 6-year-olds spent more time off-page than when tested at 24 hours post-practice, thus supporting the notion that an age advantage may exist in the long-term retention of skills due to planning-dependent aspects.

The third study: The learning of basic academic achievements, such as handwriting and reading spelling and math, share the common basic characteristics of procedural learning. This finding was shown in laboratory studies that followed the course of task learning in these domains, but a direct link between motor skill learning and academic achievements was not studied. In this study, we demonstrate associations of the learning process of the grapho-motor Invented Letter Task with basic academic achievements, as measured by age appropriate assessments. Fifty-six children aged 5-8 years who were trained on a simple grapho-motor task, improved during the training session and showed additional performance gains 24-hour post-practice that were well retained two weeks later. Their accuracy was maintained, as reported recently (Julius & Adi-Japha, 2015). In the research reported here, the handwriting (speed and legibility) and math achievements of these children was assessed concurrently with the learning experience (ILT), and in the following year. Reading speed and spelling were assessed in the following year as well. Children's handwriting and reading speed were associated with superior initial task-performance speed. Importantly, performance assessed at 24 hours post-training further contributed to the predictability of handwriting and reading speed, and was additionally associated with spelling and math performance. These results underscore the relation between the processes of learning the grapho-motor task, early academic achievements.

The findings of these three studies indicate that training repetitions must be performed in an effective manner (as a result of efficient motor control strategies) in order to achieve motor skill learning. This research has further shown that the Invented Letter Task is appropriate to study procedural skill acquisition in subjects ranging in age from kindergarten children to adults. Using this task we were able to characterize developmental patterns of procedural learning including the finding showing that all age groups including kindergarten children grade two children and young adults demonstrated learning consolidation and retention. Accuracy measurements revealed that while adults were superior in accuracy measures, kindergarten and grade two children had the same level of accuracy consistent with finding of different developmental patterns of speed and accuracy. An age related advantage in long term retention was found possibly due to a developmental difference in planning strategy. The novel finding revealing the contribution of procedural learning to the prediction of academic achievements in kindergarten and grade two children in concurrent and consecutive years was confirmed in our third study. The consolidation time-point was the most significant contributing stage of the ILT to these achievements.

Further research is needed in order to examine teaching techniques and training schedules which lead to effective learning in different age groups. Further research is also needed to investigate procedural memory deficiencies and intervention protocols in young children with and without disabilities in order to promote effective academic learning at all ages.